DISTRIBUTION OF BIRDS IN RELATION TO VEGETATION STRUCTURE AND LAND USE ALONG THE MISSOURI AND MADISON RIVER CORRIDORS: 2004 PROGRESS REPORT

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Executive Summary. Riparian habitats comprise an extremely small physical area (<1%) of the western United States. Although riparian systems are restricted in area, these areas harbor a wide diversity of birds and other wildlife. We are investigating vegetation and land use associations of breeding birds along the Madison and Upper Missouri Rivers from 2002-2004. Understanding how these factors influence avian populations will help in implementing habitat restoration and conservation strategies focused on the river system.

In 2002, we began establishing long-term avian monitoring techniques along this river system using two different survey techniques: point-count surveys focused on landbirds using habitat adjacent to the river system, and river surveys focused on species that are typically poorly detected with point-count techniques (e.g., waterbirds and waterfowl). We also began compiling and synthesizing existing information on riparian birds and have developed a database consisting of over 300 peer-reviewed articles, technical reports, theses, and dissertations on riparian birds.

In 2003, we continued to establish and initiated bird surveys at 310 point counts, accumulating over 6000 bird observations of 128 different species. The most common species using riparian habitats included Yellow Warbler, House Wren, Song Sparrow, and Brown-headed Cowbird. Other relatively rare species detected included Black-billed Cuckoo, Red-eyed Vireo, American Redstart, and Ovenbird. Vegetation types at point counts were diverse along the river system, not only including riparian habitat but also commonly including grassland, sagebrush, and conifer forest habitats. During the river surveys, we accumulated over 6300 bird observations of 58 species along 672 km of river. Common species included American White Pelican, Spotted Sandpiper, Canada Goose, and Common Merganser. Other relatively rare species detected included Long-billed Curlew, Marbled Godwit, and American Avocet. Overall, species tended to be less abundant in areas with recreational activity than in areas without activity (measured only during the surveys), but more formal analyses controlling for land cover variation have yet to be conducted. We also monitored nest success and physiological condition (refueling rates) of birds using riparian areas that differed in vegetation structure. We documented over 350 nesting attempts made by 19 open-cup nesting species. The most common nesting species were Yellow Warbler, Least Flycatcher, American Robin, and Song Sparrow. Proportional nest success across all plots and all species was 44%, with plots consisting of sparse vegetation having the lowest proportional nest success (32%), while moderate (49%) and dense

(50%) plots had approximately equal proportional success. Similar to patterns of nest success, estimates of refueling rates by migrant songbirds appeared to increase with vegetation structure. Overall, patterns of nest success and refueling rates were not correlated with bird abundance, suggesting that information on abundance alone might not provide adequate measures of habitat quality.

During the 2004 breeding season, we did more intensive surveys of breeding birds at 75 randomly selected riparian patches (166 point count locations) between Hebgen Dam and Fred Robinson Bridge. At each location we surveyed birds on two different occasions, and we measured a variety of vegetation attributes at each site (e.g., canopy height and cover, subcanopy density, species cover, etc.), including information on exotic species cover and cattle grazing intensity. We accumulated over 6500 detections of 74 species using riparian areas. Some species showed distinct geographic patterns of abundance (e.g., Red-naped Sapsuckers) and bird community composition was distinct in riparian areas between the Madison River and the Wild-and Scenic portion of the Missouri. Multiple regression models suggest that most species show positive associations with shrub cover/diversity and canopy cover. Based on the National Wetlands Inventory (NWI) Geographic Information System (GIS) coverage completed so far (from Great Falls to Fred Robinson Bridge), we determined if bird communities and vegetation structure were distinct among land cover classifications. Although there was some weak evidence for distinct vegetation structure and bird communities, there was much variation in some categories, potentially making GIS-based approaches (in the absence of other information) limited. Our predefined vegetation type classifications did a better job than NWI classifications for discriminating bird communities, but much variation still existed.

We continued river surveys in 2004, using two different approaches for determining the accuracy of the survey method. Overall, we accumulated over 15,000 detections of birds during the river surveys. Detection probabilities for different species were estimated and varied widely among species (64-96%). We will relate distribution patterns to land use and recreation activity along the river. We also continued to estimate nesting success as a function of vegetation structure, with at total of 11 sites sampled over 2003-2004. Patterns in nest success were relatively similar in 2004, with nest success generally increasing with sub-canopy cover.

Once GIS layers are completed for the river system, we will begin GIS-based analyses on how local and landscape factors can influence bird distributions in this river system. We will determine what factors best explain species distribution, whether GIS-only models can adequately predict bird distributions, and we will develop maps of predicted distributions for riparian areas across the entire river system. We will also be developing a web site that contains a synthesis of existing information on riparian bird communities, information on the current investigation of bird distribution along this river system, and links to the databases and summaries we develop. Together, these results will help in understanding and predicting the influences of land use and disturbance on bird communities, monitoring relative success of habitat restoration, and can be used in planning for restoration and conservation strategies.

Background

Riparian habitats in the western United States comprise an extremely small physical area, amounting to less than 1% of the West (Knopf et al. 1988), yet as much as 90-95% of cottonwood-willow riparian habitats have been lost in the West (Johnson and Carothers 1981). Although riparian systems are restricted in area, these areas harbor a wide diversity of birds, as well as other plants and animals. In fact, these areas have been referred to as the "aorta of an ecosystem" (Wilson 1979).

Although riparian areas contain a high diversity of wildlife, these systems have been severely stressed by a variety of anthropogenic factors, including river damming and changing in hydrology, human recreation, grazing, and other disturbances (Johnson 1992, Rood and Mahony 1995, Scott et al. 1997, Miller et al. 2003, Scott et al. 2003). These anthropogenic stressors can have negative effects on wildlife populations (Mosconi and Hutto 1982, Fletcher et al. 1999, Rottenborn 1999, Miller et al. 2003, Scott et al. 2003). For example, as human development increased in riparian areas of Colorado, riparian areas tended have fewer native trees and shrubs, and these areas supported fewer species of breeding birds (Miller et al. 2003). Likewise, Scott et al. (2003) found that bird diversity was negatively correlated with grazing intensity along the Upper Missouri River in Montana.

We investigated factors that influence distributions, reproduction, and physiological condition of birds using the Madison and Upper Missouri River system. Understanding how these factors influence avian populations will help in implementing habitat restoration and conservation strategies focused on the river system. We have the following objectives:

1) Synthesize known research information dealing with birds of the Missouri system
2) Establish a long-term monitoring plan that incorporates sampling along the river corridor
3) Identify a meaningful series of vegetation types for the purposes of sampling design and habitat-relationships modeling
4) Determine bird distribution relative to vegetation type, human settlement, and human recreational activity
5) Estimate nest success and physiological condition of landbird species that occur in association with disturbance

Methods

Synthesis of existing literature. We are conducting literature searches and compiling a database of relevant information regarding riparian birds and the Upper Missouri and Madison Rivers. In addition, we are summarizing information regarding known habitat and landscape associations of key bird species, based on their relative abundance and their Partners in Flight and U.S. Fish and Wildlife Service designations, which are distributed along the Madison and Upper Missouri Rivers (see Appendix 1).

Long-term monitoring plan. In 2002-2003, we established point count transects along the Madison and Upper Missouri Rivers, between the confluence of the Madison and just east of Fred Robinson Bridge along the Missouri (Fig. 1). We divided the river into approximately 20-km sections, and randomly picked a transect location, given the constraints that the location must be accessible and we had to be granted landowner permission. Each transect consisted of 10 point count stations, spaced approximately 300 m apart (Fig. 1; Hutto and Young 2002).

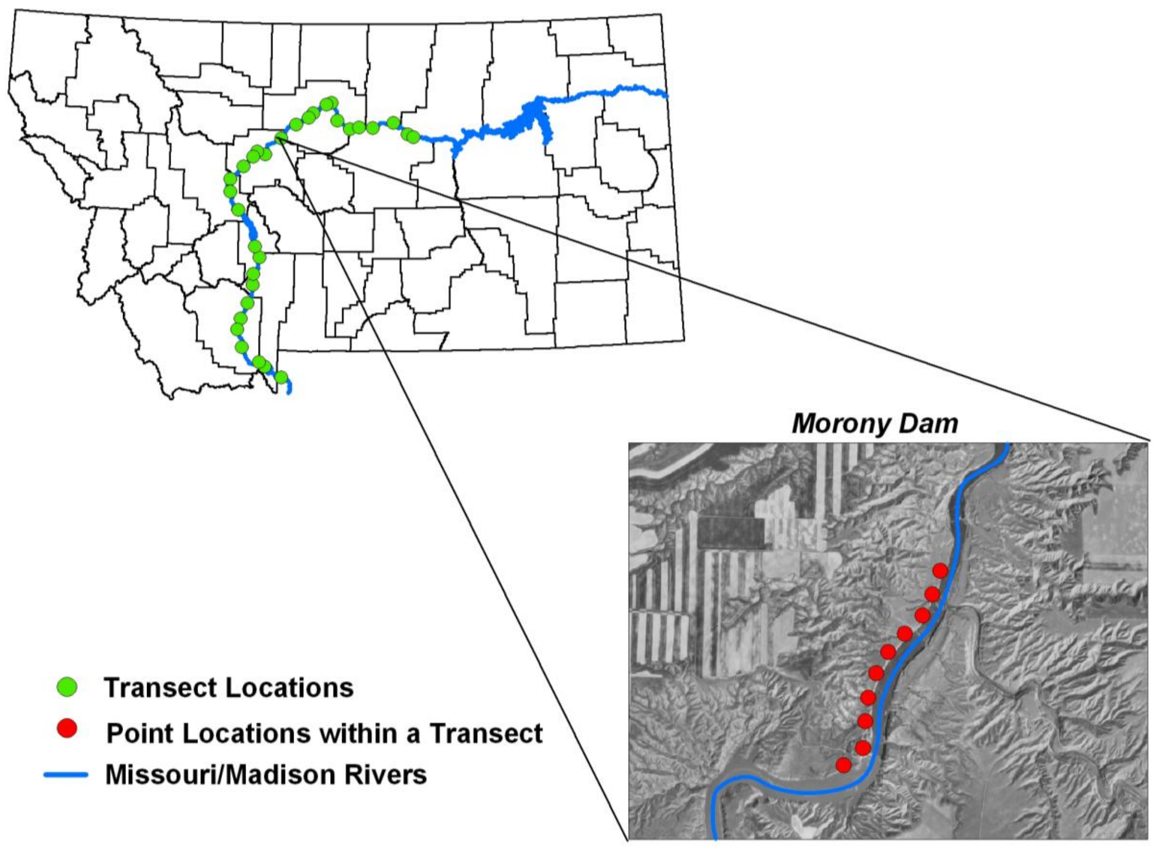

Figure 1. Point-count transects established in 2003 for long-term avian monitoring along the Upper Missouri and Madison Rivers, Montana (n = 31 transects, 310 points). The aerial photo shows an example of a transect near Morony Dam, downstream of Great Falls, Montana.

In 2003, we surveyed birds at these long-term transects to provide an anchor for future monitoring and trend analyses. We used a standard point-count protocol (Hutto et al. 1986, Ralph et al. 1995). We visited each point count once between May 25-July 10, 2003. Surveys were conducted between sunrise and 5 hours after sunrise and were not conducted during high wind velocities (≥ 20 km/hr) or during precipitation. During surveys, observers recorded all birds seen or heard, including how individuals were detected (song, visual, or call), sex of individuals, and distances of birds from the center point. Distances (m) to birds seen were estimated using a rangefinder.

In addition to land-based point count techniques, we also developed and initiated methods to survey and monitor river birds (i.e., waterbirds and raptors actively using the river for foraging and/or breeding). We surveyed river bird communities along the Madison and Upper Missouri rivers by canoe, between 20 May-10 July, 2003-2004 (Fig. 2). Two observers floated the river, recording all non-passerine birds (passerines were more effectively sampled using point count surveys described above) seen using the river or flying above the river. For each detection, we recorded the species, sex, and location along the river (in water, on island, left or right bank of river, or in flight). We also recorded all nests observed of herons, raptors, and swallow nesting colonies. All observations were recorded with a Global Positioning System.

To help determine the accuracy of the boat-based river survey, we used a simultaneous double survey approach (Magnusson et al. 1978, Graham and Bell 1989). Double surveys are a general technique where two observers independently sample the same area for species of interest. Double surveys consisted of two simultaneous surveys, where two canoes (2 observers/canoe) independently surveyed areas. Detection probabilities were estimated by considering the approach as a closed-population Lincoln-Peterson mark-recapture model (Otis et al. 1978, Magnusson et al. 1978, Graham and Bell 1989). We also determined how group size, river width, and survey speed influenced detection probabilities for common species.

In 2003, we surveyed birds between Reynold's Pass (just downstream of Quake Lake) through Fred Robinson Bridge. Between these two extents, the only areas we did not survey included a short stretch below Ennis Lake, Canyon Ferry, upper Hauser Lake, and the Great Falls metropolitan area (Fig. 2). In 2004, we divided the entire stretch of river into 23 18-40 km segments, based on available public access locations to the river. From these 23 segments, we randomly selected 14 segments for surveys (stratified geographically), and double surveys were conducted on a random sample of 6 of the 14 segments surveyed.

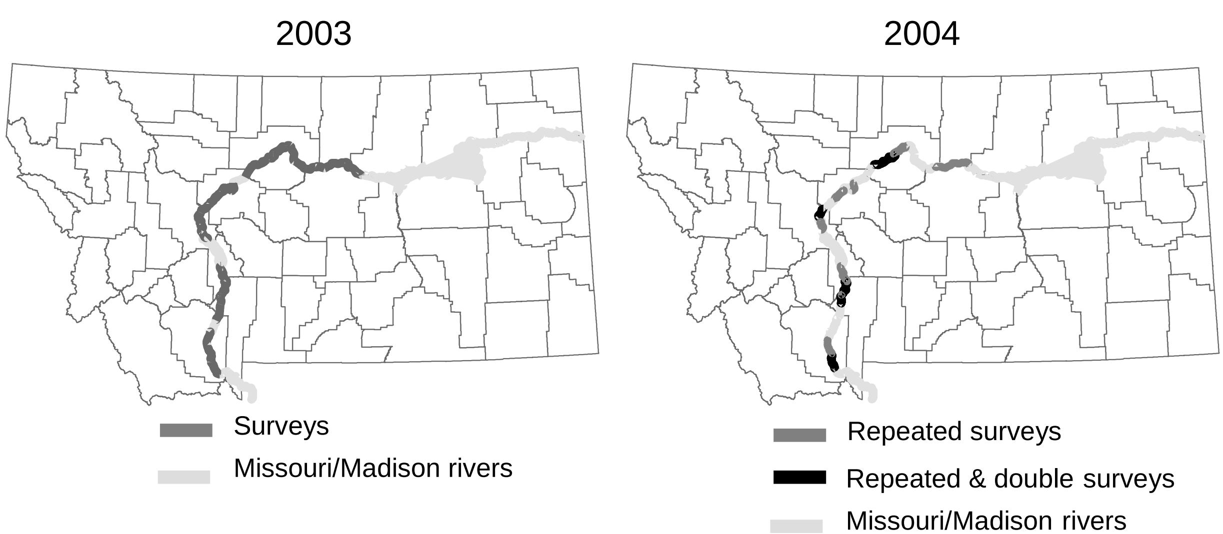

Figure 2. River survey locations used in 2003 and 2004 for establishing long-term avian monitoring along the Upper Missouri and Madison Rivers, Montana. In 2003, we surveyed each location once. In 2004, we surveyed each location twice, and we conducted double surveys (2 simultaneous surveys) on a subset (6 of 14 stretches) of the locations to estimate detection probabilities of different species.

Meaningful vegetation types. For vegetation types to be meaningful for understanding bird communities, vegetation types should reflect birds that use the areas. To determine meaningful vegetation types relevant to bird communities, we used the following approaches. First, at each point count station, we classified vegetation based on the dominant species (Table 2). Second, we classified point count locations based on the National Wetlands Inventory (NWI) geographic information system (GIS) recently developed for the river system, using the primary category for the point count area (within 50 m of the center point). Third, we made detailed measurements of vegetation structure and composition at point counts (see below). We then used data on bird abundance at point counts to determine if vegetation classifications (both our classifications and NWI classifications) contained distinct bird communities using Multivariate Analysis of Variance (MANOVA), linear discriminant analysis, and non-metric multidimensional scaling (a non-parametric ordination technique).

Bird distribution in relation to vegetation, recreation, and land use. To estimate bird distribution in relative to vegetation and land use, we focused on birds breeding in riparian habitats between Hebgen Dam and Fred Robinson Bridge. We established point count stations along the Madison and Upper Missouri Rivers, between Hebgen Dam on the Madison and just east of Fred Robinson Bridge along the Missouri (Fig. 1). To select patches, we stratified the river into three geographical sections: the Madison River, the Missouri between Three Forks and Great Falls, and between Great Falls and Fred Robinson Bridge. Within each geographical section, we randomly selected 25 riparian patches for surveying, based on digital ortho quads. The only constraint on the site-selection process was that sites were at least 50 m wide and sites were separated by > 400 m (based on semivariogram analyses on 2003 data). We used this criterion to facilitate site identification on DOQ maps. For each patch selected, we overlaid a 150m x 150 m grid, parallel to the main axis of the riparian patch, with a potential point count location in the center of each grid cell. We sampled all potential point locations within each patch (1-8 points/patch).

At each point-count station, we measured vegetation after one of the two avian surveys. Vegetation was measured at 4 sampling locations within the point-count area: one at the center of the count and three at locations 25 m from the center, at 0°, 120°, and 240°. At each sampling location we measured vegetation composition and structure for two plots: 5-m and 11.3-m radii. Within the 5 m plot, we estimated shrub cover (by species), cottonwood sapling cover (by species), ground cover structure, and exotic species cover (by species), based on overlapping ocular percentages. Ground cover categories included woody, grass, forb, standing dead vegetation, litter, bare ground. Horizontal cover was estimated using a cover board (2 m *0.5 m), where we counted the percentage of squares covered at four height categories (0-0.5, 0.5-1, etc.) in four cardinal directions, 5 m from the cover board. We used the number of cow pies within each 5 m plot as an index for grazing intensity. Within the 11.3 m plot, we counted the total number of trees (by species) and snags by size, based on three dbh categories: small (8-23 cm), medium (23-38), and large (>38 cm). We measured tree height (using a clinometer), and shrub height (shrubs > 1 m) at each location. We estimated canopy cover by averaging 4 densiometer readings (one in each cardinal direction). From these measurements, we estimated a variety of metrics related to vegetation structure and diversity. Many of these measurements were highly correlated, so we subjected variables to a Principal Component Analysis (PCA;

Table 1) to capture the variation measured in vegetation and determine what variables were explaining this variation.

Table 1. Major environmental gradients of vegetation structure, diversity, and grazing intensity described by a Principal Components Analysis. Variables with high scores explain most of the variation; similar values on the same principal component suggest high correlations among variables. PC scores > 0.4 bolded.

	PC1	PC2	PC3	PC4	PC5
Eigenvalue	3.06	2.71	1.63	1.29	1.10
Proportion explained	0.22	0.19	0.12	0.09	0.08
Cumulative explained	0.22	0.41	0.53	0.62	0.70
Eigenvector					
Grazing intensity	-0.19	-0.12	-0.07	**0.76**	0.09
Total shrub cover	**0.70**	0.09	-0.25	-0.26	0.10
Shrub diversity	**0.70**	0.00	-0.15	0.33	0.20
Total exotic spp. cover	-0.07	-0.09	**0.89**	-0.03	-0.11
Exotic species diversity	-0.03	-0.14	**0.83**	0.09	0.27
Horizontal cover	**0.80**	-0.06	0.04	-0.34	0.05
Coefficient of variation for horizontal cover	**-0.78**	0.10	0.02	-0.07	0.10
Canopy cover	0.15	**0.85**	-0.07	-0.07	0.05
Coefficient of variation for canopy cover	-0.05	**-0.90**	0.12	0.14	-0.03
Canopy height	**-0.47**	**0.71**	-0.11	0.21	0.01
Subcanopy height	**0.62**	0.35	0.07	0.09	-0.28
Number of trees	-0.08	0.33	-0.09	-0.02	0.29
Tree Diversity	0.30	0.06	0.23	**0.62**	-0.14
Number of snags	0.00	0.07	0.10	0.01	**0.89**
Interpretation	*Shrub*	*Canopy*	*Exotics*	*Grazing*	*Snags*

Land use in and around riparian sites was quantified using GIS. We estimated land cover using the MTSILC3 (Montana Satellite Imagery Land Cover Classification, 3rd generation) 30m resolution layer developed by the Spatial Analysis Lab at the University of Montana. Land cover categories included: human development, agriculture, grassland, sagebrush, shrub, riparian, deciduous (aspen), conifer, water, and rock (talus). We combined this layer with available NWI layers when available (currently from Great Falls-Fred Robinson Bridge).

We are currently developing models to predict the likelihood of occurrence and species abundance as a function local vegetation structure, grazing intensity, riparian patch size, and landscape structure. Our modeling approach includes the following steps:

1) Compare models that include local vegetation measurements only, landscape measurements only (derived from GIS layers), and models including both information. Models are developed using multiple linear regression for bird abundance or multiple logistic regression for species occurrence (for less common species). Models are compared used information-theoretic approaches (AIC_c; Burham and Anderson 1998).

2) For the best model type found in 1, compare reduced models (including tests for non-linearity in responses) to estimate the most parsimonious model describing bird abundance/occurrence.
3) For models developed in 2 that contain GIS measures, develop predictive maps for species distribution/abundance across the river system.

Step 1 is necessary and important for determining if GIS-based information is sufficient for understanding and predicting bird distributions in the river system. Step 2 is critical for developing the most parsimonious models for bird distribution, which will be more broadly applicable to large areas. Finally, step 3 will provide important deliverables to land managers for identifying "hotspot" areas for conservation, and understanding potential implications of different restoration and land management scenarios.

Results

Objective 1) Synthesis of literature

We are continuing to develop a database of riparian bird literature, focusing on the western region of the United State but also including relevant information from other regions. We have currently gathered over 300 references from peer-reviewed articles, technical reports, theses, and dissertations. We are beginning to synthesize this information into a species-based framework. In particular, we will summarize information not only on common riparian birds but also species of management concern, based on Montana Partners In Flight priority lists, and the U.S. Fish and Wildlife Service designations (see Appendix 1). Once the database is complete, we will make the references available to the general public over the internet.

Objective 2) Long-term monitoring plan

Landbird approach. We developed a long-term monitoring plan and established monitoring routes throughout the river system. Point count survey locations and landowner information are noted in Appendix 1. In 2003, we modeled our sampling approach after the Northern Region Landbird Monitoring Program (Hutto and Young 2002). When applying this approach to river bird communities, three salient issues emerged: 1) spacing points 300 m apart tended to miss important, albeit small, riparian areas, 2) conducting 10 points/transect was difficult in some areas because difficulties in access, such as river crossings, slowed sampling, and 3) in riparian areas, detection profiles as a function of distance from the center point fell off markedly after 50 m (Fig. 3). In the future we recommend reducing distances between adjacent points to 150 m (see 2004 below), which is warranted (in terms of statistical independence) if point count radii are fixed at 50 m (due to detectability), and reducing transects to 8 points/transect.

In 2004, our point counts were focused in randomly selected riparian patches along the river system (see Appendix 1 for details). For these counts, we sampled each point twice during the breeding season and we constrained count radii to 50 m (based on Fig. 3). Overall, one sampling visit only picked up approximately 70% of the species detected across both visits (Fig. 4). In addition, detection profiles declined for many species, even within 50 m. To accurately sample diverse riparian communities, more than one visit is important for estimating species richness and detecting less-common species, and detection probabilities need to be addressed. There are a variety of ways to deal with detection probabilities (Nichols et al. 2000, Buckland et al. 2001, Farnsworth et al. 2002), each of which makes certain assumptions. Distance sampling approaches or removal models are two approaches that only require some ancillary data that can easily be recorded with conventional point counts; these methods need to be tested to assess their utility.

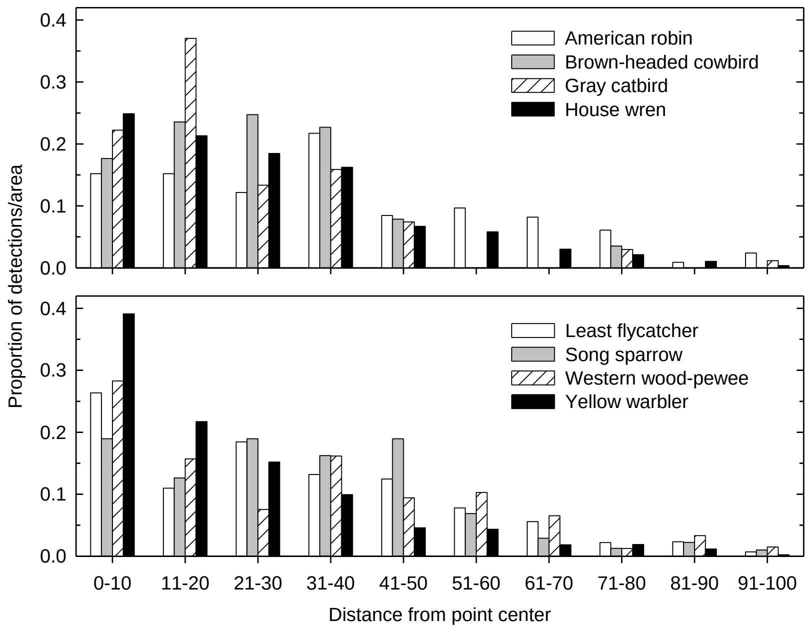

Fig. 3. Point count detection profiles for common species in riparian areas, 2003.

Waterbird approach. We used a boat-based approach to survey waterbirds along the river system. Overall, one sampling visit only picked up approximately 59% of the species detected across both visits (Fig. 4). Detection probabilities of species, estimated using the

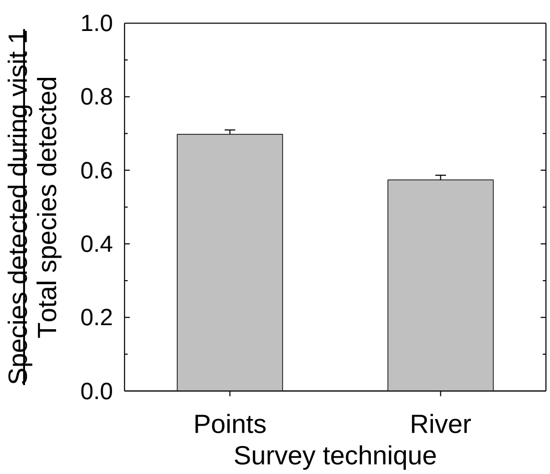

Fig. 4. The percent of species detected during the first visit (relative to total detected during 2 visits) for each monitoring technique, 2004.

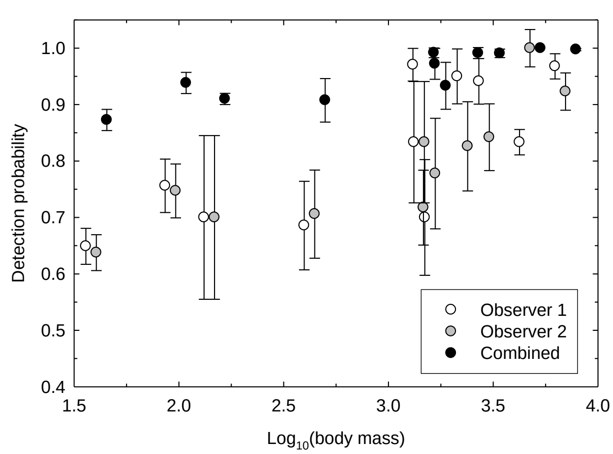

Fig. 5. Detection probabilities as a function of species' body mass for Observer 1, Observer 2, and combined (Probability that at least one observer detects an individual).

double survey approach, for each observer ranged from 64-96%, and combined detection probabilities (the likelihood of at least one canoe detecting an individual) were consistently high (93% across all species). Detection probabilities across species were correlated with body mass ($r > 0.75$; Fig. 4), with larger species having very high detection probabilities and smaller species being less detectable (Appendix 3). Species were generally more detectable in groups than alone, but overall, there was little support for including habitat characteristics in modeling detection probabilities for the most common species.

Because of the temporal variability in species detection (Fig. 5) and the lower detection probabilities for small-bodied birds, we recommend that at least two visits should occur for future monitoring of water birds and that counts should be adjusted by estimating detection probabilities. Double surveys can be conducted on a subset of surveys, and can efficiently estimate detection probabilities for water birds.

Objective 3) Meaningful vegetation types

Based on habitat characteristics measured at long-term point count monitoring plots, we developed a series of vegetation types that help describe the overall structure of vegetation along the Missouri system, focusing primarily on riparian vegetation types (Appendix 4). We have identified two series of vegetation types: 1) a fine-resolution and 2) a course-resolution vegetation series. Although the fine-resolution vegetation types provide more detailed information, we will focus on the course-resolution vegetation types for most analyses to attain satisfactory sample sizes within each category.

We evaluated NWI coverages using two approaches. First we determined if NWI layers were better at delineating riparian habitat than other existing coverages. We compared NWI layers to the SILC III coverage. Overall, SILC III consistently overestimated riparian coverage; that is, SILC often classified areas as riparian forest when in fact the areas were not. NWI layers did consistently identify riparian forest along the river system.

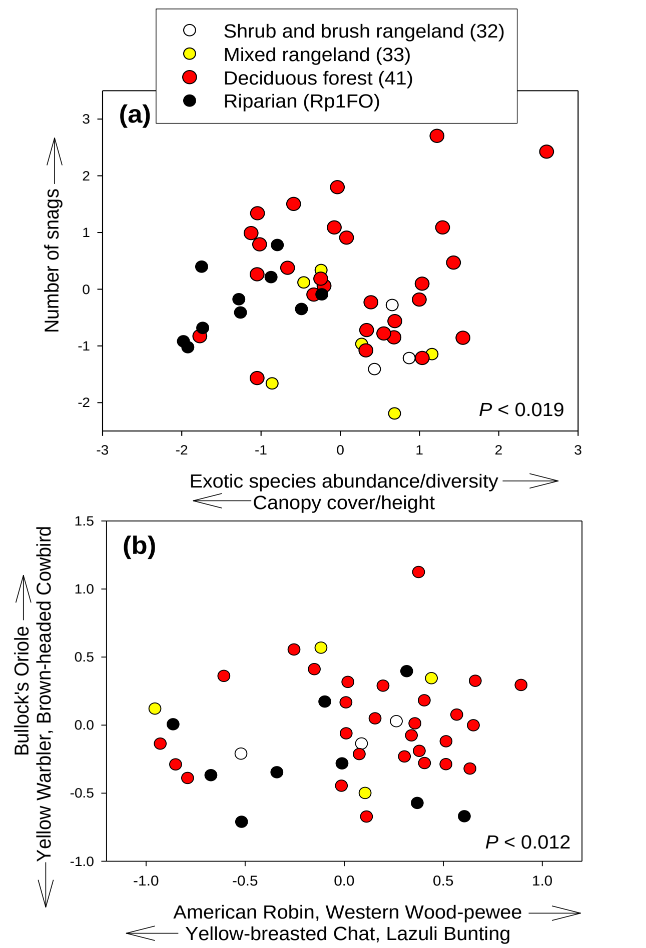

Fig. 6. (a) Local vegetation measurements (from 2004) can broadly discriminate among NWI land cover categories (based on a discriminant analysis); however, some categories(deciduous forest) contain much variation in vegetation structure. **(b)** Bird communities were statistically different among categories (based on a MRPP analysis); but, again, categories contain much variation and differences are less than for vegetation.

Based on the current NWI coverage, which samples one third of the river (from Great Falls to Fred Robinson Bridge), we determined if local vegetation measurements and bird communities could discriminate among NWI land cover categories, which would suggest that these categories provide meaningful classifications for understanding and predicting habitat and bird communities along the river system. Overall, our detailed vegetation measurements could discriminate among land cover (Fig. 6A); however, one common category, deciduous forest, showed much variation in vegetation structure. An analysis to determine if bird communities were distinct among categories was statistically significant (Fig. 6B), but patterns were less strong than for vegetation structure. Overall, one land cover categories (deciduous forest) showed the entire gradient in bird community variation.

We repeated analyses for the vegetation types we identified, listed in Appendix 4. As expected, these vegetation categories were more distinct in terms of overall vegetation structure ($P < 0.001$) and bird communities ($P < 0.001$). This is not unexpected, because these categories were made while visiting sites and are more refined than course NWI categories. Below, we estimate how each does in explaining species distribution and abundance, addressing whether NWI land cover is adequate for understanding and predicting the distribution and abundance of riparian birds.

Objective 4) Bird distribution in relation to habitat and recreation.

During the 2004 breeding season, we focused on rigorously examining how vegetation, recreation, and other anthropogenic activity (e.g., cattle grazing) influences bird communities by integrating GIS information, riparian focused bird surveys, and detailed habitat measurements.

One land use practice that showed strong correlations with vegetation structure was the relative cattle grazing intensity:

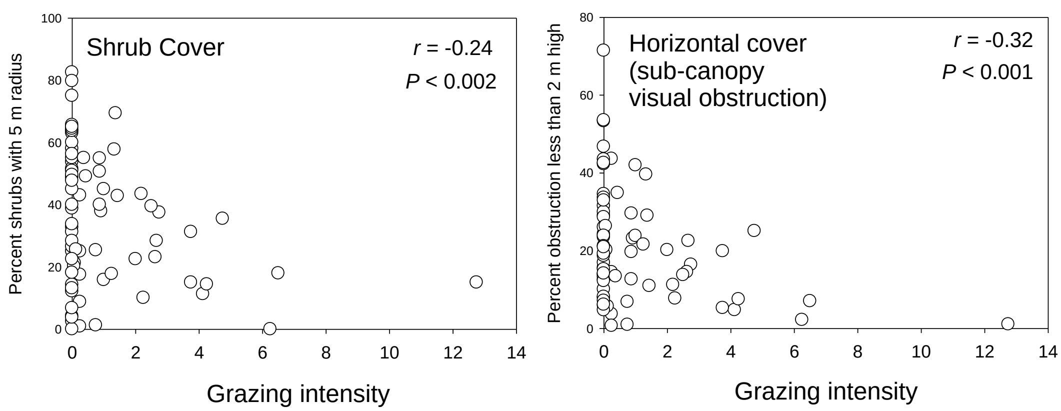

Fig. 7. Correlation between grazing intensity (# cow pies/5m radius) and two measures of sub-canopy structure: the percent shrub cover and horizontal cover (percent visual obstruction on a coverboard).

Grazing appears to set an upper limit on sub-canopy/shrub cover; that is, when grazing is absent, areas may or may not have a strong sub-canopy component, which is likely based on factors such as geomorphology and succession history. However, with grazing present, sub-canopy growth and development is likely impaired, effectively setting an upper bound on cover.

We are currently developing models to predict the likelihood of occurrence and species abundance as a function local vegetation structure, grazing intensity, riparian patch size, and landscape structure. As an example of this approach, we modeled the relative abundance (birds/point) of Least Flycatchers between Great Falls and Fred Robinson Bridge. We only used information for this area because this is the only area where GIS layers are complete. Overall, a landscape only model was sufficient in modeling abundance, and within the candidate landscape variables, the most parsimonious model only included the amount of riparian habitat in the landscape (Fig. 8).

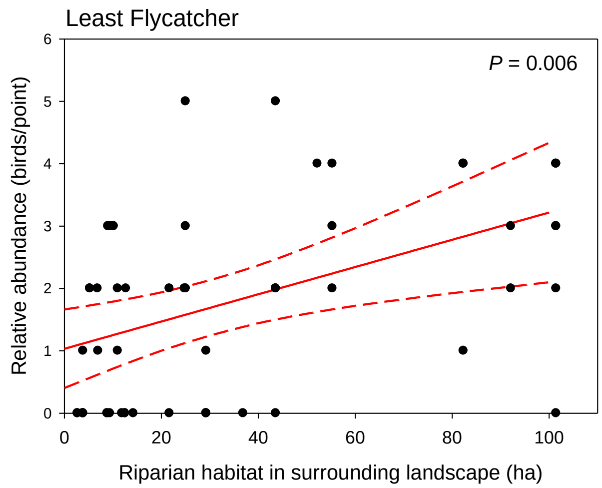

Fig. 8. The best model for describing Least Flycatcher relative abundance only included the amount of riparian habitat in the surrounding landscape.

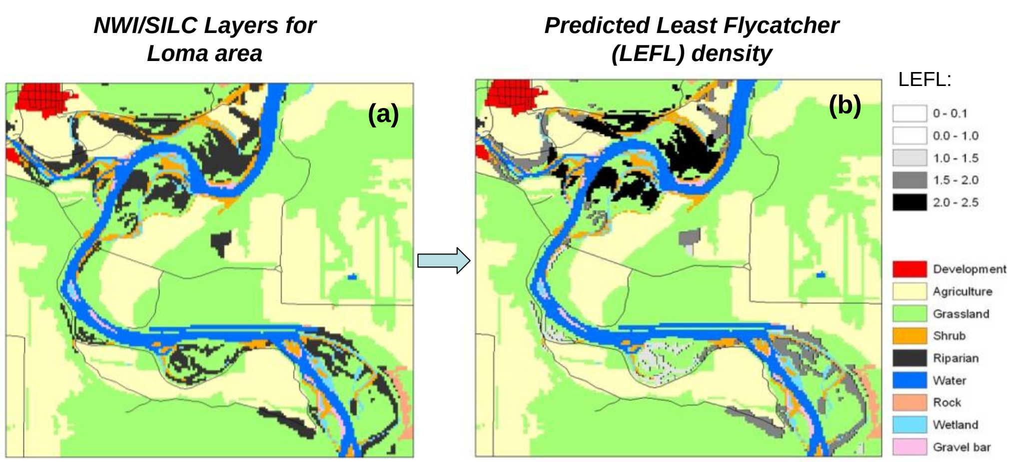

Fig. 9. An example of combining GIS layers (a) and survey data (from Fig. 8) to generate A predictive bird abundance map for Least Flycatcher (b).

These predictive maps will be an extremely valuable resource to managers, conservationists, and bird enthusiasts. An important next step will be to estimate the accuracy and precision of these predictive maps.

We focused on whether and how recreational activity influences river birds by recording all locations of activity during our boat-based river bird surveys. Recreational activity ranged from anglers walking along the river's edge, to motorboats traveling down the center of the river. During these surveys, avian species richness changed dramatically as a function of recreational activity. Overall, 42 % of the variation in species richness could be explained by the frequency of angler and boats along the river ($P < 0.008$ for both factors). Interestingly, the direction of the effects differed, with increases in angler activity (along shores; not in boats) being correlated with slight increases in species richness, whereas increase in boat activity was strongly correlated with declines in species richness.

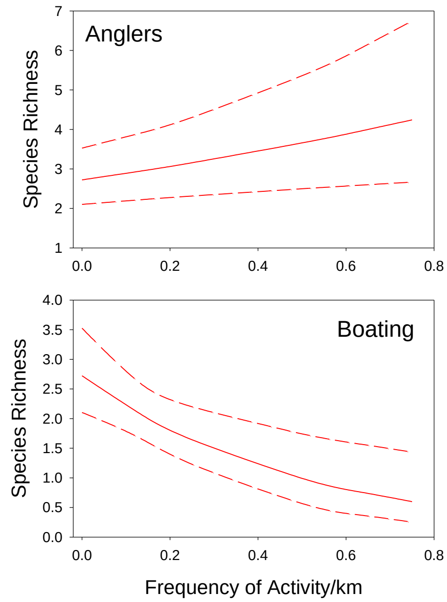

Fig. 10. Changes in species richness (# species/km) with recreational activity.

Future Directions and Timeline

In 2005, we continue our research and monitoring of avian populations along the Madison and Upper Missouri rivers. Specifically, we will:

1. Continue point-counts in riparian areas, which will provide an anchor for estimating long-term trends of bird populations along this river system. These surveys will be designed to validate models from previous survey data.

2. Continue to refine and validate vegetation types used for understanding bird-habitat relationships. In particular, we will begin distinguishing younger and older cottonwood stands and we will estimate the similarity of bird communities among vegetation types to determine if these categories actually reflect distinct avian communities.

3. Continue synthesizing literature and develop a website for disseminating information on the riparian birds of the Missouri and Madison rivers. Some data from long-term monitoring transects will also become available to managers and the public at http://www.birdsource.org/LBMP/.

4. Finish analyses, finish synthesizing existing data and finish developing the web site, present information at professional conservation meetings, write the final report summarizing the project, and submit manuscripts for publication in peer-reviewed journals.

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Appendix 1. Targeted avian species for literature syntheses. We targeted these species based on Partners in Flight (PIF) priority status, USFWS status, or if species were relatively common in riparian habitats along the Upper Missouri/Madison River system.

Species	Species Code	PIF Priority I	PIF Priority II	PIF Priority III	USFWS	Common riparian
American goldfinch	AMGO					X
American redstart	AMRE			X		
American robin	AMRO					X
American white pelican	AWPE			X		
Bald eagle	BAEA		X		X	
Black-billed cuckoo	BBCU		X			
Brown-headed cowbird	BHCO					X
Bullock's oriole	BUOR					X
Caspian tern	CATE		X			
Cedar waxwing	CEDW					X
Common yellowthroat	COYE					X
Downy woodpecker	DOWO			X		
Eastern kingbird	EAKI					X
European starling	EUST					X
Forster's tern	FOTE		X			
Franklin's gull	FRGU		X			
Golden eagle	GOEA				X	
Gray catbird	GRCA			X		
House wren	HOWR					X
Killdeer	KILL			X		
Lazuli bunting	LAZB		X			
Long-billed curlew	LBCU		X		X	
Least flycatcher	LEFL			X		
Least tern (interior)	LETE	X			X	
Marbled godwit	MAGO		X		X	
Mourning dove	MODO					X
Ovenbird	OVEN			X		
Red-eyed vireo	REVI		X			
Red-naped sapsucker	RNSA		X		X	
Red-winged blackbird	RWBL			X		
Song sparrow	SOSP			X		
Sharp-shinned hawk	SSHA			X		
Swainson's hawk	SWHA			X	X	
Trumpeter swan	TRUS	X				
Veery	VEER			X		
Warbling vireo	WAVI			X		
Western wood-pewee	WEWP					X
Willow flycatcher	WIFL		X			
Wilson's phalarope	WIPH			X	X	
Yellow-billed cuckoo	YBCU		X		X	
Yellow -breasted chat	YBCH					X
Yellow-headed blackbird	YHBL			X		
Yellow warbler	YWAR					X

Appendix 2. Total bird detections during point counts and river surveys along the Madison and Missouri Rivers, 2003-2004. For point counts, flyovers were only included in the total for each species. In 2003, point counts were conducted in all habitat types, while in 2004 point counts were conducted only in riparian areas.

		Points					
	Species	2003		2004		River surveys	
Species	Code	<50m	Total	<50m	Total	2003	2004
American avocet	AMAV	0	3	0	0	1	17
American coot	AMCO	0	0	0	0	1	35
American crow	AMCR	3	40	3	3	26	53
American goldfinch	AMGO	49	151	160	344	0	33
American kestrel	AMKE	10	25	14	20	20	0
American redstart	AMRE	6	9	16	21	0	0
American robin	AMRO	94	279	303	338	0	0
American wigeon	AMWI	0	5	0	0	24	57
Audubon's warbler	AUWA	13	28	3	3	0	0
American white pelican	AWPE	0	163	1	70	955	1581
Bald eagle	BAEA	1	16	1	6	32	68
Bank swallow	BANS	2	128	0	47	770	1835
Baltimore oriole	BAOR	1	1	0	0	0	0
Barn swallow	BARS	0	3	0	0	2	0
Black-billed cuckoo	BBCU	0	1	0	0	0	0
Black-billed magpie	BBMA	17	98	32	45	0	0
Black-capped chickadee	BCCH	25	71	70	70	0	0
Belted kingfisher	BEKI	2	8	6	15	28	50
Blue-winged teal	BWTE	0	0	0	0	0	89
Brown-headed cowbird	BHCO	113	258	215	290	0	0
Black-headed grosbeak	BHGR	13	26	61	68	0	0
Blackpoll warbler	BPWA	0	0	2	2	0	0
Bobolink	BOBO	1	7	0	0	0	0
Brewer's blackbird	BRBL	4	8	11	14	0	0
Brewer's sparrow	BRSP	9	12	0	0	0	0
Brown thrasher	BRTH	5	5	3	4	0	0
Bufflehead	BUFL	0	0	0	0	3	0
Bullock's Oriole	BUOR	44	69	178	186	0	0
Canada goose	CAGO	0	71	0	10	956	2280
California gull	CAGU	0	70	0	21	191	129
Calliope hummingbird	CAHU	2	2	0	0	0	0
Canvasback	CANV	0	0	0	0	0	2
Canyon wren	CANW	0	3	0	0	1	0
Caspian tern	CATE	0	6	0	0	12	37
Canyon wren	CAWR	0	2	0	0	0	0
Clay-colored sparrow	CCSP	9	22	12	12	0	0
Cedar waxwing	CEDW	60	121	120	190	0	0
Chipping sparrow	CHSP	26	52	1	1	0	0
Cinnamon teal	CITE	0	0	0	0	13	24

Appendix 2. *Continued.*

		Points				River surveys	
		2003		2004			
Species	Code	<50m	Total	<50m	Total	2003	2004
Clark's grebe	CLGR	0	0	0	0	0	1
Cliff swallow	CLSW	1	150	0	63	1327	3074
Common goldeneye	COGO	0	4	0	0	3	1
Common grackle	COGR	5	26	43	73	0	0
Cooper's hawk	COHA	0	2	2	2	0	4
Common loon	COLO	0	0	0	0	1	1
Common merganser	COME	0	41	0	6	253	441
Common nighthawk	CONI	0	9	2	5	6	82
Common raven	CORA	3	37	1	6	27	54
Common snipe	COSN	1	6	0	0	0	1
Common yellowthroat	COYE	29	70	36	37	0	0
Double-crested cormorant	DCCO	0	107	0	8	164	548
Dark-eyed junco	DEJU	7	11	1	1	0	0
Downy woodpecker	DOWO	14	18	62	67	0	0
Dusky flycatcher	DUFL	6	11	0	0	0	0
Eared grebe	EAGR	0	0	0	0	1	0
Eastern kingbird	EAKI	51	109	131	154	0	0
European starling	EUST	57	288	282	384	0	0
Field sparrow	FISP	2	6	0	0	0	0
Forster's tern	FOTE	0	1	0	0	1	3
Franklin's gull	FRGU	0	7	0	2	161	139
Gadwall	GADW	0	1	0	1	26	89
Great blue heron	GBHE	0	19	2	14	76	116
Great-horned owl	GHOW	5	6	11	11	0	3
Golden eagle	GOEA	0	0	0	0	6	21
Gray catbird	GRCA	57	86	201	208	0	0
Gray jay	GRJA	0	1	0	0	0	0
Greater yellowlegs	GRYE	0	0	0	0	0	8
Greater white-fronted goose	GWFG	0	0	0	0	0	1
Green-winged teal	GWTE	0	0	0	0	0	13
Hairy woodpecker	HAWO	3	11	6	6	0	0
House finch	HOFI	8	10	23	24	0	0
House sparrow	HOSP	0	0	1	2	0	0
Horned lark	HOLA	0	1	0	0	0	0
Hooded merganser	HOME	0	0	0	0	2	3
House wren	HOWR	187	336	571	579	0	0
Killdeer	KILL	5	40	3	9	156	372
Lark sparrow	LASP	10	32	7	7	0	0
Lazuli bunting	LAZB	22	36	23	24	0	0
Long-billed curlew	LBCU	0	1	0	0	2	1
Least flycatcher	LEFL	87	157	341	378	0	0
Least sandpiper	LESA	0	0	0	0	0	1

Appendix 2. *Continued.*

		Points					
		2003		2004		River surveys	
Species	Code	<50m	Total	<50m	Total	2003	2004
Lesser scaup	LESC	0	0	0	0	18	1
Lincoln's sparrow	LISP	4	7	0	0	0	0
Marbled godwit	MAGO	0	0	0	0	2	1
Mallard	MALL	7	45	0	13	314	660
Marsh wren	MAWR	2	2	5	5	0	0
MacGillivray's warbler	MGWA	0	0	1	1	0	0
Mountain bluebird	MOBL	1	2	1	1	0	0
Mountain chickadee	MOCH	13	29	0	0	0	0
Mourning dove	MODO	42	205	300	355	0	0
Northern flicker	NOFL	13	87	108	122	0	0
Northern harrier	NOHA	0	1	0	2	3	8
Northern pintail	NOPI	0	0	0	0	0	19
Northern shoveler	NOSH	0	1	0	0	0	16
Northern rough-winged swallow	NRWS	2	16	0	75	8	0
Northern waterthrush	NOWA	0	0	2	3	0	0
Orange-crowned warbler	OCWA	1	1	0	0	0	0
Olive-sided flycatcher	OSFL	0	5	0	0	0	0
Osprey	OSPR	0	10	0	8	49	86
Ovenbird	OVEN	2	8	9	15	0	0
Pileated woodpecker	PIWO	0	0	0	1	0	0
Pinyon jay	PIJA	1	4	0	0	0	0
Pine siskin	PISI	0	5	0	0	0	0
Prairie falcon	PRFA	0	0	0	0	2	1
Red-breasted nuthatch	RBNU	0	0	3	3	0	0
Ring-billed gull	RBGU	0	4	0	9	15	154
Ruby-crowned kinglet	RCKI	5	14	0	0	0	0
Redhead	REDH	0	2	0	0	0	0
Red-eyed vireo	REVI	6	9	13	16	0	0
Red-naped sapsucker	RNSA	5	8	21	22	0	0
Rock dove	RODO	2	31	0	4	66	348
Rock wren	ROWR	3	52	0	0	1	0
Ring-necked pheasant	RPHE	0	52	5	5	0	2
Red-tailed hawk	RTHA	2	28	7	21	79	102
Red-winged blackbird	RWBL	45	148	28	41	0	0
Ruddy duck	RUDU	0	0	0	0	0	1
Sandhill crane	SACR	0	14	3	5	0	17
Say's phoebe	SAPH	0	1	0	0	0	0
Savannah sparrow	SAVS	32	65	0	0	0	0
Sora	SORA	1	1	0	0	0	0
Song sparrow	SOSP	66	157	168	171	0	0
Spotted sandpiper	SPSA	4	74	3	4	399	1137
Spotted towhee	SPTO	39	96	46	50	0	0

Appendix 2. *Continued.*

		Points					
		2003		2004		River surveys	
Species	Code	<50m	Total	<50m	Total	2003	2004
Sharp-shinned hawk	SSHA	2	2	0	0	1	0
Swainson's hawk	SWHA	0	3	2	5	4	9
Swainson's thrush	SWTH	1	6	0	0	0	0
Townsend's solitare	TOSO	0	2	0	0	0	0
Tree swallow	TRES	15	156	71	366	47	0
Trumpeter swan	TRUS	0	1	0	0	1	2
Turkey vulture	TUVU	0	1	0	0	22	55
Unknown corvid	UNCO	0	0	0	0	0	3
Unknown duck	UNDU	0	0	0	0	15	65
Unknown flycatcher (*Empidonax* spp.)	UNEM	2	2	1	1	0	0
Unknown gull	UNGU	0	6	0	0	0	1119
Unknown hummingbird	UNHU	0	2	0	0	0	0
Unknown raptor	UNRA	0	0	0	0	0	18
Unknown species	UNKN	3	3	1	1	0	3
Unknown tern	UNTE	0	2	0	0	0	3
Unknown yellowlegs	UNYE	0	0	0	0	1	0
Veery	VEER	1	1	25	27	0	0
Vesper sparrow	VESP	6	40	1	1	0	0
Violet-green swallow	VGSW	2	56	0	3	21	135
Warbling vireo	WAVI	11	36	78	81	0	0
White-breasted nuthatch	WBNU	1	7	5	5	0	0
White-crowned sparrow	WCSP	15	40	2	2	0	0
Western grebe	WEGR	0	5	0	0	11	40
Western kingbird	WEKI	15	37	31	34	0	0
Western meadowlark	WEME	9	191	2	2	0	0
Western screech owl	WESO	0	0	1	1	0	0
Western tanager	WETA	2	2	2	2	0	0
Western wood-pewee	WEWP	64	167	178	183	0	0
White-throated sparrow	WTSP	0	0	1	1	0	0
White-throated swift	WTSW	0	11	0	3	8	273
Willet	WILL	0	0	0	0	0	4
Willow flycatcher	WIFL	9	29	42	43	0	0
Wild turkey	WITU	0	1	0	0	0	0
Wilson's phalarope	WIPH	0	0	0	0	2	5
Wilson's warbler	WIWA	0	1	2	2	0	0
Wood duck	WODU	0	2	0	0	9	89
Yellow -breasted chat	YBCH	17	67	37	41	0	0
Yellow-headed blackbird	YHBL	2	11	0	0	12	0
Yellow warbler	YWAR	320	592	937	955	0	0
Total species		83	124	74	91	55	62
Total observations		1864	6069	5103	6568	6361	15643

Appendix 3. Estimated detection probabilities for species (all species where total number of detections, *n*, > 6) and species groups (e.g., gulls) using a double survey approach, 2004.

Species/group	n	Observer 1		Observer 2		Combined	
		$\hat{p}_1$	SE($\hat{p}_1$)	$\hat{p}_2$	SE($\hat{p}_2$)	$\hat{p}_t$	SE($\hat{p}_t$)
American White Pelican	67	0.968	0.022	0.923	0.033	0.998	0.002
Double-crested Cormorant	24	0.700	0.102	0.778	0.098	0.933	0.042
Great Blue Heron	24	0.950	0.049	0.826	0.079	0.991	0.010
Canada Goose	40	0.941	0.040	0.842	0.059	0.991	0.008
Mallard	45	0.686	0.078	0.706	0.078	0.908	0.038
Common Merganser	47	0.971	0.029	0.717	0.066	0.992	0.009
Killdeer	103	0.756	0.047	0.747	0.048	0.938	0.019
Spotted Sandpiper	308	0.649	0.032	0.638	0.032	0.873	0.019
Osprey	14	0.833	0.108	0.833	0.108	0.972	0.027
Belted Kingfisher	12	0.700	0.145	0.700	0.145	0.910	0.070
Species groups:							
Teal	13	0.778	0.139	0.636	0.145	0.919	0.067
All ducks	129	0.753	0.044	0.695	0.045	0.925	0.019
Shorebirds	415	0.676	0.027	0.663	0.027	0.891	0.014
Gulls (*Larus* spp.)	9	0.875	0.117	0.875	0.117	0.984	0.022
Raptors	29	0.731	0.087	0.864	0.073	0.963	0.025
Total	773	0.750	0.018	0.718	0.018	0.930	0.008

Appendix 4. Vegetation cover type categories used in point count analyses.

Fine-resolution	Description	Course-resolution	Description
Urban	Areas of human development, including housing, roads, etc.	Urban	Areas of human development, including housing, roads, etc.
Irrigated cropland Dry cropland	Crops with irrigation (e.g., alfalfa) Crops without irrigation (e.g., barley)	Cropland	Irrigated and non-irrigated crops
Native grassland Exotic grassland	Grasslands dominated by native species (e.g., crested wheatgrass) Grasslands dominated by exotic species (e.g., leafy spurge, *Euphorbia esula*)	Grassland	Native and/or exotic dominated grasslands
Big sagebrush Silver sagebrush	Shrubsteppe dominated by big sagebrush (*Artemisia tridentata*) Shrubsteppe dominated by silver sagebrush (*A. cana*)	Sagebrush	Big sage or silver sage dominated areas
Shrub	Open areas dominated by shrubs (e.g., skunkbush, *Rhus trilobata*)	Shrub	Open areas dominated by shrubs (e.g., skunkbush)
Juniper woodland Douglas-fir Lodgepole pine Mixed conifer	Conifer forest dominated by juniper (*Juniperus* spp.) Conifer forest dominated by *Pseudotsuga menziesii* Conifer forest dominated by *Pinus contorta* No dominant conifer species	Conifer	Coniferous forest, including doug-fir, ponderosa pine
Aspen	*Populus tremuloides* stands	Aspen	*Populus tremuloides* stands
Water	Riverside or open water habitat	Water	Riverside or open water habitat
Wet meadow	Sedge or rush dominated wet grasslands	Wet meadow	Sedge or rush dominated wet grasslands
Marsh	Emergent vegetation (e.g., *Typha* spp.)	Marsh	Sedges, emergent vegetation (e.g., *Typha* spp.)
Box elder			
Green ash			
Willow shrub Willow flats	Open *Salix* spp. dominated areas Expansive floodplain *Salix* spp. dominated areas	Willow	*Salix* spp. dominated areas
Narrowleaf cotton-wood with subcanopy Black cottonwood with subcanopy Plains cottonwood with subcanopy Young cottonwood with subcanopy	*P. angustifolia* with any shrub or subcanopy layers *P. trichocarpa* with any shrub or subcanopy layers *P. deltoides* with any shrub or subcanopy layers	Cottonwood with subcanopy	Plains cottonwood with subcanopy
Narrowleaf cotton-wood without subcanopy Black cottonwood without subcanopy Plains cottonwood without subcanopy Young cottonwood without subcanopy	*P. angustifolia* without any shrub or subcanopy layers *P. trichocarpa* without any shrub or subcanopy layers *P. deltoides* without any shrub or subcanopy layers	Cottonwood without subcanopy	*P. deltoides* or *P. angustifolia* without any shrub or subcanopy layers
Mixed conifer-deciduous riparian Mixed deciduous riparian	Deciduous riparian vegetation and confer trees with no dominant species Deciduous riparian vegetation with no dominant species	Mixed riparian	Riparian vegetation with no dominant species